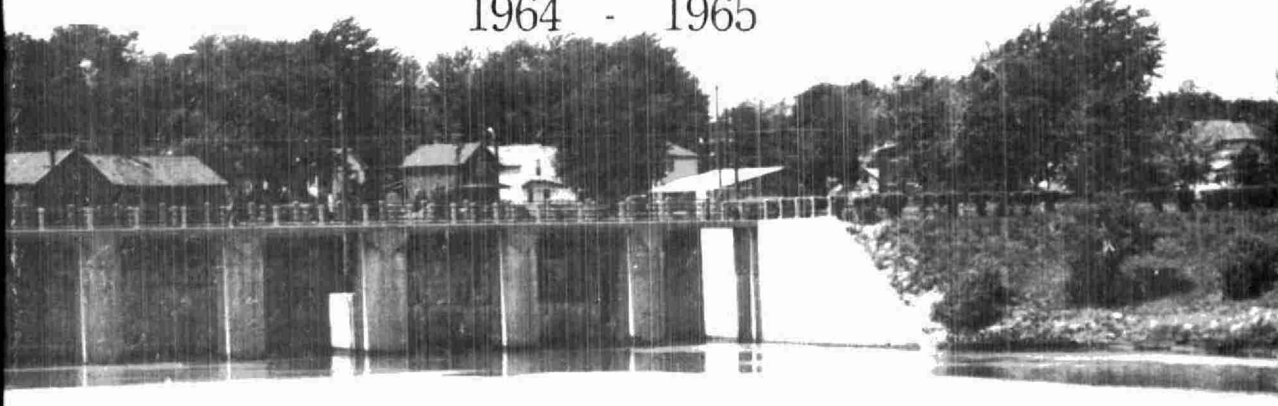
WATER QUALITY SURVEY

of the

WELLAND RIVER

1964 - 1965



ONTARIO WATER RESOURCES COMMISSION

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ACKNOWLEDGEMENTS

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CHAPTER I

INTRODUCTION

BACKGROUND

The Welland River and its tributary Lyon's Creek are unnecessarily exploited for municipal and industrial wastewater disposal at and below the City of Welland. A supplementary flow of 250 cfs had been diverted to the river by the Welland Board of Commissioners until February 1964, at which time the flow rate was reduced because of changes in water works operating procedures. It became readily apparent that unless provision could be made to continue the diversion for dilution needs in the lower river, very offensive conditions would prevail in that section of the stream.

In view of the serious pollution already existing and the prospect of reductions in dilution water, the Ontario Water Resources Commission undertook an investigation to study in detail the effects of pollution on stream quality and the significance of the diverted dilution water.

SCOPE

Physical, chemical, bacteriological and biological characteristics were evaluated in the river above Welland as well as in the lower river through the City of Welland to its confluence with the Niagara River at Chippawa. With the knowledge that during drought conditions, natural river discharges at Welland may be at or near zero, determinations of the amount and significance of the dilution water diverted at the filtration plant were a major aspect of the survey. The complicating influence of the backwater effects related to Niagara River regulation for power purposes is not well defined and no attempt was made in this preliminary study to evaluate the significance of this factor as it related to water quality in the river.

The field studies reported herein involved six intensive surveys at monthly intervals from June to November 1964. These studies coincided with periods of reduced dilution flow during which time repairs were being made to the Chippawa-Queenston Power Canal and the normal flow pattern in the Welland River was altered.

Water use practices and pollution control are described in Chapter III. The factors considered in the survey program are presented in Chapter IV; whereas, the results and significance of the field studies are discussed in Chapters V and VI, respectively.

CHAPTER II

SUMMARY AND RECOMMENDATIONS

Two major sources of pollution contribute to serious water quality impairment in the lower Welland River. Domestic sewage and industrial wastes from the City of Welland are disposed of without treatment directly to the river. Approximately eight miles downstream from the city, Cyanamid of Canada Ltd. (Welland Works), discharges wastes containing high levels of ammonia.

Recently the City of Welland announced plans for construction of a primary sewage treatment plant to be followed by the installation of secondary treatment facilities. The planning schedule calls for a start on construction of the primary plant this year with provision of secondary treatment by 1967.

Supplementation of the natural flow in the Welland River, which is frequently zero during drought conditions is essential for wastewater dilution needs in the lower river. Under the present conditions with no treatment provided by the city, unacceptable water quality is experienced at the maximum possible diversion rate of 170 cfs. With the provision of primary and secondary sewage treatment by the City of Welland, it is possible that lesser rates of diversion will enable maintenance of satisfactory water quality. Determination of the magnitude of the necessary diversion will, however, await further studies of water quality following the installation of the primary and secondary treatment facilities.

In the following the results of the survey of each river section or reach are summarized.

Water quality in the upper river was relatively satisfactory for a slow-moving turbid stream. Dissolved oxygen concentrations were acceptable and the density of coliform organisms low indicating that no appreciable pollution was present in the river. The abundance of many varieities of fish and genera of bottom organisms, as well as a variety and abundance of zoo plankton confirmed the satisfactory quality of the water in this reach. Slight degredation in water quality, changes in fish life and reduction of bottom organisms indicated some pollution in the river just above Welland, presumably as the result of upstream movement of wastes from the city.

Untreated sewage and industrial waste discharges from the City of Welland were responsible for pollution of the river from a point two miles above the city limits, downstream to Port Robinson. Excessive levels of coliform organisms, indicative of domestic sewage, prevailed throughout this eight-mile reach. Industrial wastes were responsible for elevated phenol and iron concentrations. During the low flow period in July, the wastewater mixture caused the dissolved oxygen content of the river to be depressed below 40% saturation. While not sufficient to keep the D.O. content above the recommended lower limit of 4.0 ppm, the addition of 140-150 cfs of dilution water during the summer of 1964 did prevent the development of malodorous conditions related to complete oxygen depletion.

This critical section of the river was polluted to the degree that it was rendered undesirable for industrial water-supply purposes and unfit for recreational use. Aesthetically, pollution was demonstrated by grey, medicinal water; reddish, oily surface films; and black malodorous sludge deposits. Below the city, a reduction in the number of species of fish, genera of bottom organisms and populations of zoo plankton furthur illustrated the serious damage to water quality caused by wastes discharged from the city.

Discharges of wastes from Cyanamid of Canada Ltd. (Welland Works) to the river and Thompson's Creek were responsible for levels of ammonia toxic to most animal life in the seven mile section of the river from Thompson's Creek to Chippawa. The presence of exceptionally small populations of only one species of fish and two genera of bottom organisms illustrated the severe effects of the wastes from Cyanamid. The accumulation of banks of solids was noted in the main channel at the confluence of Thompson's Creek. A varied and abundant population of algae flourished below Cyanamid presumably promoted by high concentrations of nitrogen and phosphorus. Elsewhere, algae populations were uniformly low.

Excessive coliform densities and high 5-day BOD levels in the last four mile reach were attributed to domestic and industrial wastes discharging from the Stanley Road settling basin operated by the City of Niagara Falls. Under normal conditions of canal operation, flow in this section of the river is reversed and conveyed to the Niagara River via the power canal.

Excessive bacterial contamination of Lyon's Creek within the City of Welland, especially in the vicinity of the Bradley Street pumping station, was indicated. Severe oxygen depletion was frequently observed with septic conditions noted on occasion. Excessive 5-day BOD, phenol, iron, nitrogen and

phosphorus levels were prevalent. Near the confluence with the Welland River, water quality conditions improved enough to support several species of fish and several varieties of bottom organisms.

RECOMMENDATIONS

(1) The city should continue to provide for the diversion of as much water as possible at the Welland filtration plant until full secondary sewage treatment is in operation.

(2) Arrangements should be made for the continuation of a long term supply of dilution water to the lower river. Further studies will be required to establish the magnitude of the necessary diversion.

(3) The City of Welland should provide secondary treatment for all wastewater originating within the city.

(4) Cyanamid of Canada Ltd. (Welland Works) should develop a program of wastewater treatment to remove the high concentrations of ammonia now discharged to the Welland River and Thompson's Creek.

(5) The discharge of industrial and domestic wastes to Lyon's Creek should be curtailed by connection of the Bradley Street pumping station and the Welland Tubes Ltd. lagoon effluent to the City of Welland sewer system.

(6) The Stanley Road settling basin, operated by the City of Niagara Falls should be connected to the sewer system tributary to the City of Niagara Falls water pollution control plant.

CHAPTER III

THE WELLAND RIVER - RESOURCES AND USES

1. GEOGRAPHY

The Welland River drains some 350 square miles of the Haldimand Clay Plain, an area of little relief sloping from west to east. The river originates on the eastern edge of Ancaster Township and flows 80 miles to the Niagara River. Although the average gradient is three feet per mile, steeper gradients contribute to erosion in the head water zone. The sediment load is reflected in turbidity downstream especially the final sluggish 50 miles where the gradient is less than one foot per mile. Lyon's Creek, a slow-moving tributary, traverses the south-eastern corner of the City of Welland and joins the main Welland River one mile above the Niagara River.

The City of Welland (population 36,712) is situated on the Welland River approximately thirteen miles from its former confluence with the Niagara River at the Village of Chippawa. The river flows diagonally across the city for approximately five miles in a meandering fashion and passes under the Welland Ship Canal through an inverted syphon arrangement. Further downstream, the construction of the Chippawa-Queenston Power Canal involved channelization of the four mile section above the original mouth to permit Niagara River water entry to the power canal.

In Figure 3-1 the survey area is outlined.

2. NATURAL AND ARTIFICIAL ASPECTS

(a) Streamflow

The natural mean daily flow of the Welland River at the Chippawa-Queenston Power Canal has been estimated by the H.E.P.C. at 540 cfs (annual basis). However, during drought periods, flow in the Welland River is nil except for the diversion from the Welland Ship Canal. The water level in the river is dependant upon the prevailing level of the Niagara River. Regulation of levels by the H.E.P.C. to maintain discharges over Niagara Falls and through the power generating plants cause daily reversals of river flow that exert a back-

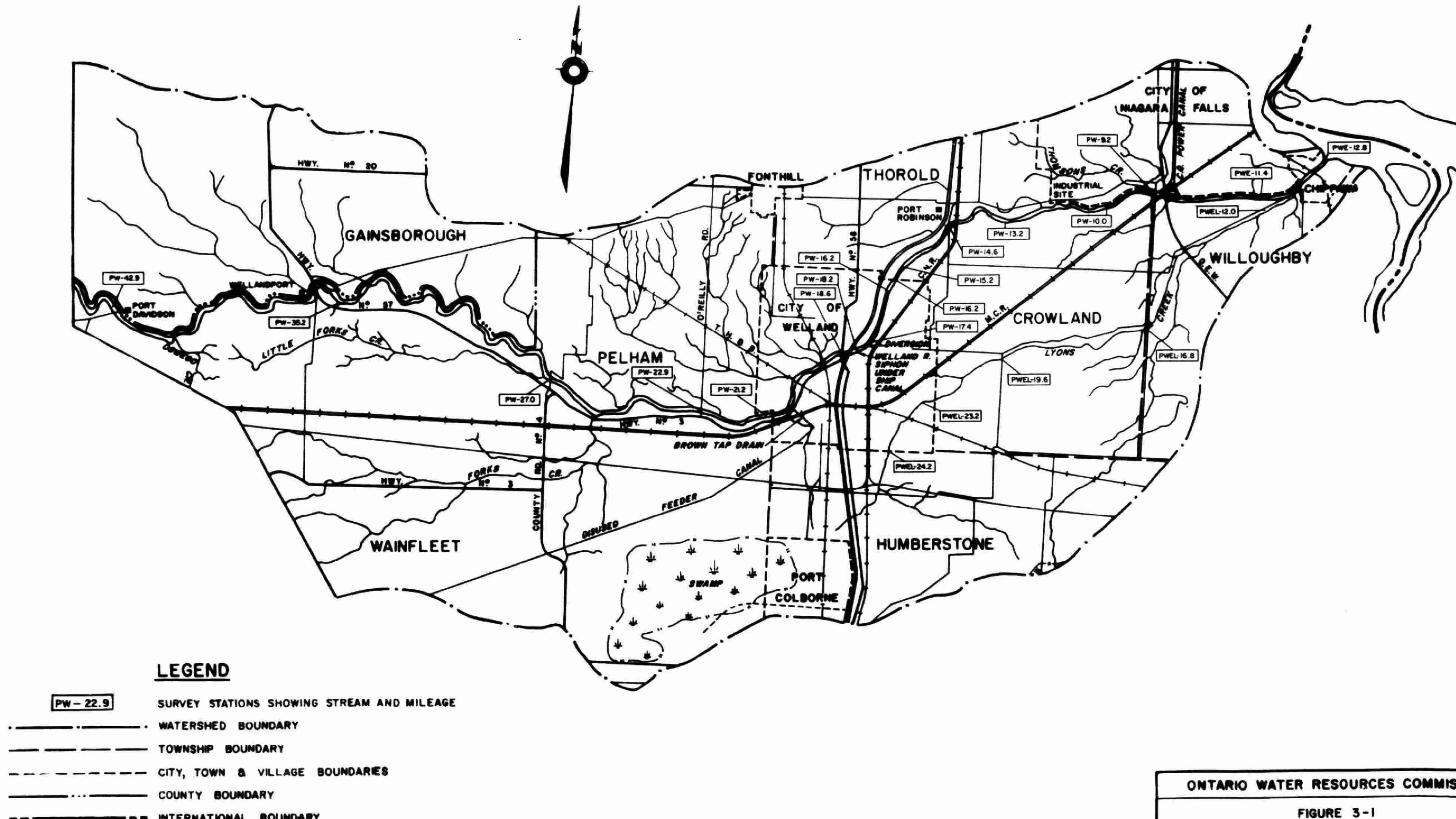

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FIGURE 3-1

WELLAND RIVER SURVEY

LOCATION OF SURVEY STATIONS

SCALE: 1 0 1 2 3 4 MILES	
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CHECKED BY: J.R.	DRAWING Nº: 64-76

water effect as far as 40 miles upstream from the mouth.

(b) Dilution Water

The artificial dilution water available at Welland is diverted from the operation at the Welland filtration plant of water turbine pumping equipment. Until February 1964, 250 cfs were diverted from the Welland Ship Canal for the operation of two water driven turbine pumps. Diversion water is leased through agreement with the St. Lawrence Seaway Authority. Each year the cost of leasing water was raised and in February 1964, the Welland Board of Water Commissioners decided to switch to the more economical electrically driven pumping units. Consequently, one turbine unit well was converted to a raw water well. Diversion flow was continued through the single turbine unit at a reduced rate.

When the Ontario Water Resources Commission expressed concern over the effect of the reduced water flow on river water quality, the City of Welland passed a resolution in April 1964, to continue to divert 250 cfs until a secondary sewage treatment plant was placed in operation.

(c) Chippawa-Queenston Power Canal

In April 1964, the H.E.P.C. closed the canal inlet gates near the Montrose Bridge and dewatered the Chippawa-Queenston Power Canal for reconstruction and repairs. As a result, the Welland River resumed its natural course to the Niagara River. Backwater effects related to the operation of the control weir in the Niagara River exerted a decided effect on river levels at Welland which resulted in very sluggish river flows during the period from April to November 1964. In preparing for the canal repairs a temporary intake was constructed for the Niagara Falls filtration plant by H.E.P.C. to draw water directly from the Niagara River and thereby maintain satisfactory water quality for the city water supply.

3. WATER SUPPLY

Upstream from Port Robinson there are no water supplies obtained from the Welland River; whereas, below this point, the following supplies are drawn:

TABLE - 3-1

WATER SUPPLIES FROM THE WELLAND RIVER

Name of Supply	Use	Treatment	Average Pumpage
Cyanamid of Canada Ltd. (Welland Works)	Industrial Processing and Cooling	Floc.[1] and Settling	20.0 mgd
Ford Motor Co. of Canada Ltd. - Glass Fabricating Operation	Domestic Industrial	Complete[2]	0.20 mgd
Canadian Carborundum Co. Ltd.	Industrial Processing and Cooling	nil	3.60 mgd
Norton Co. of Canada Ltd.	Industrial Cooling	nil	5.7 mgd
City of Niagara Falls	Municipal Supply	Complete[2] Treatment	8.4 mgd

1 - Flocculation
2 - Coagulation, settling, filtration, chlorination

Canadian Carborundum Co. Ltd., Norton Co. of Canada Ltd. and the City of Niagara Falls draw water supplies from that portion of the river usually containing Niagara River water. Cyanamid of Canada Ltd. and Ford Motor Co. of Canada Ltd. are located above the power canal and due to reversal of flow in the river, Cyanamid of Canada Ltd. could conceivably draw diluted process wastes into the company intake. The Ford Motor Co. of Canada Ltd. supply is adversely influenced by the impaired quality of the river water.

4. WASTEWATER DISPOSAL

In the upstream reaches the river receives small amounts of pollution from malfunctioning septic tank systems at Warner, Port Davidson and Wellandport. As well, a small creamery at Winger discharges process wastes to Forks Creek during the winter months. However, the known amount of polluting material is small by comparison with the wastewater loadings discharged downstream.

The City of Welland discharges large volumes of domestic sewage and industrial wastes to the river through 35 combined outfall sewers. Cooling water excluded, it has been estimated that the total volume of untreated waste flow approximates 8.0 mgd. Industrial wastewater included discharges from a steel mill, plating shops, pipe manufacturers, textile processers, chemical and rubber industries. Wastes with characteristics which include large quantities of 5-day BOD, solids phenols, iron, nitrogens, phosphorus, etc. are contributed by these sources. Lyon's Creek receives discharges from the Bradley Street pumping station and effluent from the Welland Tubes Ltd. lagoon.

In its lower reaches, the river receives industrial discharges containing enormous quantities of ammonia, solids and BOD from Cyanamid of Canada Ltd. Domestic and industrial wastes are discharged by B.F. Gooderich Chemicals, Ford Motor Co. of Canada Ltd., Glass Fabricating Plant and Norton Co. Ltd. Effluent from the Stanley Road primary settling basin in Niagara Falls and the secondary sewage treatment plant at Chippawa enter the river near the confluence with the Niagara River.

5. POLLUTION CONTROL

Serious conditions of pollution are evident in the final thirteen miles of the Welland River because the river is used to receive raw or inadequately treated sewage. The Ontario Water Resources Commission treatment requirements depend on local conditions and usually vary from a minimum of primary treatment to secondary treatment. In some cases, higher than secondary degree of treatment may be required. In order to preserve acceptable river water quality, adequate sewage and industrial waste treatment facilities must be provided. As well, the diversion of water from the Welland Canal to the Welland River must be provided to continue flow augmentation and assist in the self-purification capacity of the receiving water.

CHAPTER IV

SURVEY CONSIDERATIONS

Water quality conditions in a stream are usually most critical during the summer months when streamflow is low and water temperatures elevated. Based on these considerations, six monthly surveys of the Welland River were performed between June and November 1964. Physical and chemical parameters were selected to best illustrate the existing pollution. Bacteriological examinations and biological studies were carried out to further illustrate stream conditions. Diversion flow from the Welland Ship Canal was measured and the effects of the diversion on water quality noted.

1. SAMPLING STATION LOCATIONS

Originally seven water quality sampling ranges were selected on the main river commencing at mileage point PW-27.0, approximately six miles upstream from the western boundary of Welland extending downstream to Montrose Bridge. The range descriptions were as follows:

1.	-	PW-27.0	at County Road 4 bridge
2.	-	PW-22.9	at O'Reilly's bridge
3.	-	PW-18.6	at Highway 58 bridge
4.	-	PW-18.2	300' below diversion water tailrace
5.	-	PW-17.4	at 100' below 96" Ø sewer
6.	-	PW-14.6	at Port Robinson bridge
7.	-	PW-9.2	at Montrose bridge

These ranges were initially sampled on June 10th, 1964 and subsequently that year on July 7th, August 5th, September 14th, October 14th and November 25th. Additional ranges were established on July 7th at:

8.	-	PW-16.2	at Cambridge Road
9.	-	PW-15.2	at Carl Road
10.	-	PW-10.0	at Argyle Road

As a result of the adverse conditions in the vicinity of Cyanamid of Canada Ltd., two downstream ranges were added in September at:

11. - PWE-11.4 at Paradise Acres
12. - PWE-12.8 at bridge at Chippawa

Similarly on Lyon's Creek, four ranges were established at:

1. PWEL-24.2 at Townline Road
2. PWEL-23.2 at Ontario Road
3. PWEL-19.6 at Cook's Mills
4. PWEL-16.8 at County Road 28

2. FLOW MEASUREMENT

Records of flow measurement at the gauge at Merritt's Church show that streamflow in the Welland River during the summer months is close to nil. Measurements made during the June survey at stations PW-27.0 and PW-22.9 on the Welland River showed flow to be zero feet per second. Flow measurements on Lyon's Creek at PWEL-24.2 also approximated zero feet per second. As a first approximation for the purpose of determining available dilution flow during dry periods in the summer months, natural flow in the river at Welland can be neglected.

River flow determinations were made at the Welland water works tailrace during the June, August, September and November surveys. During the first two and the last surveys, the turbine wicket gates were opened to various settings while during the September survey, the wicket gates were opened wide.

3. PARAMETERS OF POLLUTION

(a) Chemical-Physical

Forty-ounce samples were obtained for chemical-physical analysis. Samples were delivered to the OWRC laboratory within 24 hours of sampling.

Biochemical Oxygen Demand (5-Day)

The 5-day BOD is a laboratory measurement of the amount of oxygen consumed by micro-organisms in stabil-

izing organic material in an aerobic environment at a temperature of 20°C. over a five-day test period. It is therefore an indirect measurement of the amount of organic material contained in a sample. Stream conditions are considered acceptable if the 5-day BOD does not exceed 4.0 parts per million (ppm).

Dissolved Oxygen

Immediately following the discharge of deoxygenating wastes to a watercourse, aquatic organisms begin to utilize these materials as food, and by metabolism requiring oxygen, cause depletion of the dissolved oxygen present in the stream. If deoxygenation is sufficient, complete oxygen depletion can occur and septic, malodorous conditions will develop. Restoration of dissolved oxygen occurs by the exchange of oxygen from the air to the water and by photosynthesis of green aquatic plants. Acceptable stream conditions are indicated if the dissolved oxygen content never falls below 4.0 ppm or 40% saturation.

Dissolved oxygen tests were carried out at each station in the field using the Winkler Alsterburg method. Simultaneous temperature readings were taken.

Nitrogens

Domestic wastes contain large quantities of nitrogenous materials derived from the breakdown of waste protein material. Therefore, analysis for nitrogen in its various forms is a reliable indication of the presence of pollution in a stream. High values of free ammonia and nitrogen as total Kjeldahl are an indication of fresh pollution while the presence of nitrates and nitrites indicates that pollution has occurred at an earlier time and has been almost completely oxidized.

Under normal conditions in streams, freshly polluted waters produce high values for total Kjeldahl (organic nitrogen); usually BOD values are high also at this time. As oxidation begins to occur, the value of free ammonia increases, but as it continues and the BOD level falls, values of free ammonia and total Kjeldahl decrease and traces of nitrites and nitrates begin to appear. When the pollutant is almost completely oxidized and BOD values fall within acceptable limits, values of total Kjeldahl, free ammonia and nitrite approach zero while the value of nitrate rises.

Phosphorus

Total and soluble phosphorus are good indicators of domestic wastes because these wastes are rich in phosphorus compounds. Phosphorus is a nutrient and the organisms involved in the biological processes of waste stabilization all require a small amount of phosphorus in the water for reproduction. This amount is usually not sufficient to measurably reduce the concentrations within a short distance.

Phenol

Phenol is a term applied to a wide range of phenolic compounds which include those hydroxy derivatives of benzene which can be determined by the Gibb's method. The presence of phenols in concentrations as low as 1.0 part per billion (ppb) imparts a readily detectable medicinal taste to chlorinated water supplies. At greater concentrations toxicity to fish develops with surviving species usually exhibiting an unpleasant taste. The Commission objective is to maintain the average phenol concentration below 2.0 ppb. The maximum phenol concentration should not exceed 5.0 ppb.

Iron

Ferrous iron is quite soluble in water and low concentrations are often found naturally in streams. Wastewaters from industries producing or utilizing steel in production are usually rich in iron compounds and as a result, iron levels in receiving waters usually rise. Concentrations of iron in excess of 0.3 ppm are usually grounds for rejection of water for supply purposes.

Solids

The analysis for solids usually include tests for total, suspended and dissolved solids. Suspended solids indicate the measure of undissolved solids of organic or inorganic nature; whereas, the dissolved solids are a measure of those in solution. Land erosion, sewage and industrial wastes are significant sources of suspended solids.

Excessive amounts of suspended solids in water can cause interference with domestic and industrial water treatment processes, harmful effects to fish and other aquatic life by clogging the gills and respiratory passages of aquatic fauna, turbidity which interferes with light transmission and can interfere with boating and aesthetic enjoyment of the water.

When a part of the suspended solids settles out on stream and lake bottoms as sludge or bottom deposits, damage to aquatic life can occur since these deposits blanket the bottom killing eggs and essential fishfood organisms and destroying spawning beds.

Turbidity

Turbidity is a measure of the interference of the passage of light through water caused by suspended colloidal material. It may be caused by a natural sediment load (particles of clay or rock) by organic material or by inert particles from industrial wastes.

Excessive turbidity restricts the development of fish and other biological life forms, but its major sanitary significance is in relation to water supplies and the reduction in efficiency of disinfection of these supplies.

Apparent Colour

Apparent colour includes not only true colour due to substances in solution contributed by decaying vegetable and organic matter but also that due to suspended matter. Colour content is expressed in Hazen units.

(b) Bacteriological

Six-ounce samples for total coliform examination by the Membrane Filter technique were taken to correspond with the sampling for chemical quality.

Total Coliform Organisms

Coliform organisms consist mainly of that group of bacteria living in the intestinal tract of warm-blooded animals and man. The presence of large numbers of these in a stream indicates the possibility that disease producing organisms may also be present. The OWRC recommends that streams having coliform counts in excess of 2,400 coliforms per 100 ml. of sample should not be used for recreational purposes.

(c) Biological

Biology as an Indicator of Stream Pollution

Examination of plant and animal communities of a watercourse provides information of practical value in the interpretation of water quality. Pollutants may alter

the stream environment and affect the aquatic community. The extent of biological imbalance indicates the degree to which water quality has been altered. Plant and animal communities reflect not only water quality over a long period of time prior to examination and place the interpretation of water quality on meaningful terms, but the data collected also provides a useful basis for future comparison of water quality. For these reasons the fish, bottom fauna, zooplankton and plants were examined at several points on the Welland River in 1964.

CHAPTER V

SURVEY RESULTS

Following results on the magnitude and significance of the diversion, the various parameters of pollution are discussed in relation to the Welland River and Lyon's Creek. The analytical results are included in the report appendices.

1. DIVERSION FLOW MEASUREMENT

Measurements at stations PW-27.0 and PW-22.9 on the Welland River during the June survey revealed that flow approximated zero. Similarly flow at PWEL-24.2 on Lyon's Creek was zero.

Flow measurements were made at the Welland filtration plant tailrace during the June, August, September and November surveys. The results of these measurements are listed in Table 5-1.

TABLE 5-1

WELLAND RIVER SURVEY - DIVERSION WATER FLOW MEASUREMENTS

Date	Time	Test	Flow cfs	Total Pumpage ppm	Line Pressure psi	Differential Head ft.
June 10 1964	12:00 noon	1	144.2	4900	64.0	7.2
	2:30 pm	2	148.0	5100	57.0	7.0
	3:30 pm	3	226.8	5200	62.0	7.0
Aug. 5 1964	11:15 am	1	139.3	4800	62.0	7.05
	11:50 am	2	148.0	4800	62.0	7.05
Sept.15	12:00 noon	1	275.5	turbine blocked wicket gates wide open		7.1
Nov. 25	10:00 am	1	176.4	wicket gates at 4.8 setting		8.9

During the June survey, the turbine was operating normally and flow was measured at approximately 145 cfs. This amount of diversion was continued until September when the water turbine was blocked and the wicket gates were opened wide. Flow reached 275 cfs but vibrations in the plant were so great that this setting could not be maintained for more than a few hours. The turbine was then returned to normal operation until November when the wicket gates were permanently opened about one-half by a manually operated crank to a dial setting of 4.8. This resulted in a flow of about 175 cfs.

2. PARAMETERS OF POLLUTION

(a) Welland River

Biochemical Oxygen Demand (5-Day)

The beneficial effects of dilution water on water quality are readily apparent in the monthly BOD averages for the June, July and August surveys. Figure 5-1 shows the drop in BOD levels immediately below the diversion channel at PW-18.2. An increase in BOD was noted during the October and November surveys when values approached 4.0 ppm in Welland.

In the downstream reach, below Cyanamid of Canada Ltd., BOD values rose sharply each month of the survey with the greatest increase being noted during the November survey. Figure 5-1 clearly shows the increased BOD loading at stations PW-10.0 and PW-9.2. High values in this reach were attributed to the wastes discharged from Cyanamid of Canada Ltd. (Welland Works) and the waste discharges from the Stanley Road settling basin.

Dissolved Oxygen

Dissolved oxygen concentrations were low during the months of June, July, August and September when the natural streamflow was close to zero cfs. The most unsatisfactory conditions were observed in July when the D.O. content fell below the recommended lower limit of 4.0 ppm between stations PW-18.6 in Welland and PW-15.2 in Port Robinson.

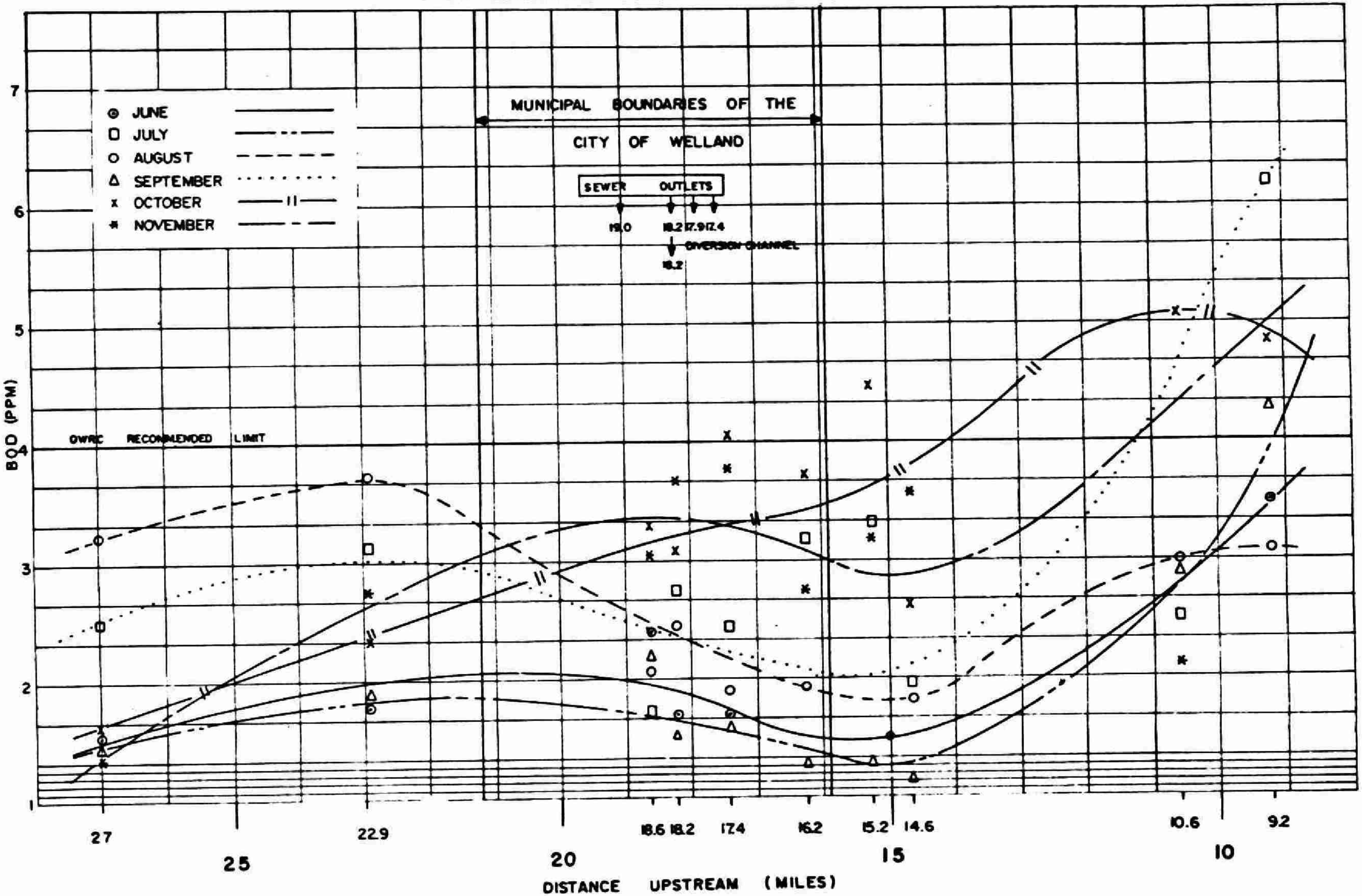
From station PW-10.0 to the river's mouth at Chippawa, profuse algae growths resulted in supersaturation of the water with dissolved oxygen during the daylight hours.

In October and November, oxygen levels showed a noticeable increase over the previous four surveys. In-

WELLAND RIVER SURVEY - 1964

5 DAY BIOCHEMICAL OXYGEN RESULTS (BOD) PPM

FIG 5-1



creased oxygen solubility and decreased biological activity related to lower temperatures may have accounted for this situation.

Figure 5-2 clearly shows the monthly variations in dissolved oxygen content at each station down the river.

Nitrogen

While values for free ammonia and total Kjeldahl indicated that there was some recent pollution in the Welland River above Welland, elevated values at PW-18.6 and PW-18.2 in Welland indicated that large amounts of fresh domestic wastes were being discharged to the river. Below the city, values for free ammonia and total Kjeldahl began to decrease while values of nitrate, an indicator of stabilized pollutant, increased showing that some self-purification was taking place in the river. The addition of dilution water from the Welland Ship Canal aided in this oxidation process.

The most significant increase in nitrogen concentrations occurred at PW-9.2 below Cyanamid of Canada Ltd. where monthly levels of free ammonia were well above the 2.5 ppm limit which is toxic to most species of fish at pH values between 7.4 and 8.5. pH in this reach averaged 8.2. Drastic reductions in aquatic fauna populations below Cyanamid tend to support the chemical findings.

Phosphorus

Phosphorus levels both upstream and downstream from the City of Welland were high due to the discharge of municipal and industrial wastes. The backwater effects carried these wastes alternately upstream and downstream from the city. The dilution water, although itself slightly enriched with phosphorus, kept phosphorus levels from rising sharply from the Welland filtration plant downstream to Port Robinson. Further downstream, the raised levels were caused by industrial waste flow from Cyanamid of Canada Ltd. (Welland Works) and the Stanley Road settling basin.

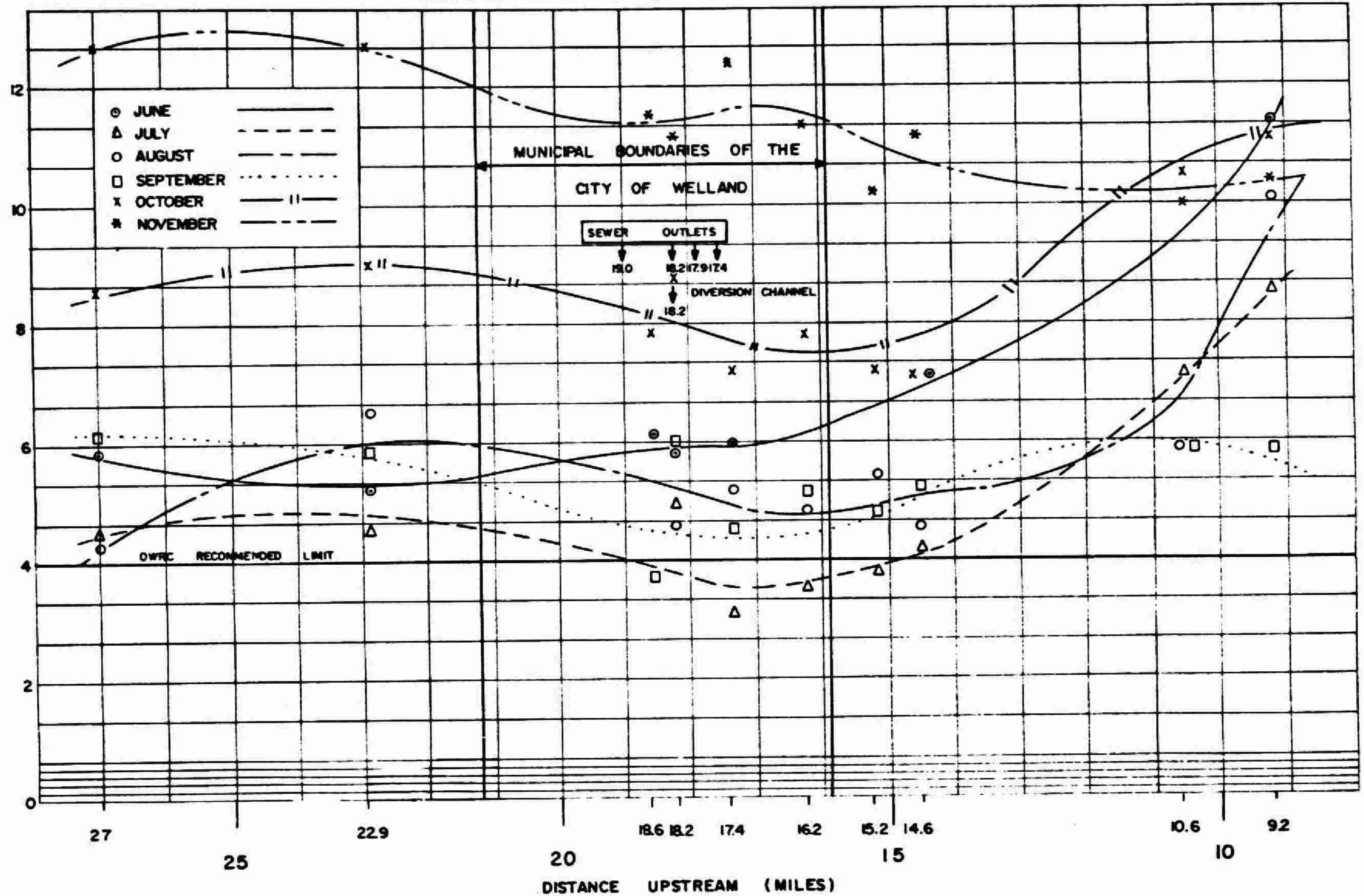
Phenol

The major sources of phenolic waste in the City of Welland are the steel and associated manufacturing industries. The phenolic waste discharged from the city sewers in Welland and in particular the discharges from the Atlas Steel sewer covered at times the entire river surface

WELLAND RIVER SURVEY - 1964

DISSOLVED OXYGEN (PPM) Vs MILES UPSTREAM

FIG 5-2



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with oily material. During each survey, an oily odour was noticeable from the westerly city limits to Port Robinson.

The average monthly phenol concentrations in the Welland River, including the diversion water, exceeded the objective. The quality of the diversion water reflects navigational activity on the Welland Ship Canal.

Iron

Concentrations in the river above Welland indicated a naturally high iron content averaging about 5 ppm at PW-27.0. Through the City of Welland, iron levels averaged about 1.5 ppm with an increase to about 2 ppm below the Atlas Steel Co. sewer. The decreased iron concentration through Welland was probably due to settling of the iron-laden sediment. Sludge banks were noted along the sides of the river between stations PW-18.2 and PW-17.4.

Turbidity and Suspended Solids

The Welland River flows through a clay plain and erosion usually results in high turbidity and suspended solids levels. This is reflected by the sample results from stations PW-27.0 and PW-22.9. Settling caused by the backwater effect and the influence of the diversion water reduced suspended solids and turbidity levels below Port Robinson to a point where the river could be used for industrial water supplies.

Apparent Colour

The apparent colour level at station PW-27.0 averaged 200 Hazen units. However, as suspended particles settled out below Welland, apparent colour was reduced to an average of 20 units.

Bacteriological

Total Coliform Organisms

Severe bacteriological pollution of the Welland River was evident throughout the six-month survey from a point one mile above the municipal limits of Welland downstream to Port Robinson. Coliform counts in excess of 75,000 organisms per 100 ml. were common in this reach.

Below Port Robinson, the toxic free ammonia concentrations in the wastes from Cyanamid of Canada Ltd.

(Welland Works) probably contributed to the reduction in coliform organisms noted at stations PW-10.0 and PW-9.2. The wastewater discharge from the Stanley Road settling basin was responsible for the higher downstream levels.

Biological Findings

Fish Populations

Eighteen species of fish were taken by seine net from the Welland River; not a large number of species for a Southern Ontario stream, but probably representative of heavily silted, slow-moving waters. The following species were taken: white sucker, carp, golden shiner, creek chub, emerald shiner, spottail shiner, bluntnose minnow, brown bullhead, tadpole madtom, mudminnow, northern pike, killifish, rock bass, pumpkinseed sunfish, white crappie, black crappie, yellow perch and Johnny darter.

The rock bass and creek shub were found in the lower portion of Lyon's Creek but not in the Welland River. The golden shiner, crappies, pike, mudminnows and Johnny darter were not taken from Lyon's Creek, but the latter two species were taken rarely in the Welland River. The numbers of fish of each species caught at the stations designated in Figure 5-3 are provided in Appendix 2, Table 7-2.

Effects of Pollution on Fish

Twelve species of fish found at stations PW-42.9, PW-35.2 and PW-27.0, above major sources of pollution, provide an excellent basis for comparison with fish populations in downstream waters.

The population at station PW-21.2 was decidely different from upstream populations. The relative abundance of the species was altered with minnows and bullheads occurring in great numbers. Although a greater standing crop of fish was apparent the population lacked other fish. The changes in fish population indicated mild pollution probably related to back-circulation from sewers located a short distance downstream in Welland.

Only five species of fish were taken at station PW-16.2. The standing crop of pollution-tolerant carp was at a high level, indicating considerable enrich-

ment of the river water and sediments. The seven species which failed to inhabit this zone were probably excluded because of periodic reductions in dissovled oxygen, toxic components of industrial wastes, alterations in the abundance of food, or a combination of all these factors.

More fish of a greater number of species were captured at station PW-13.2, which indicated partial recovery from the heavy waste load received in Welland. The recovery process continued downstream until effluents from Cyanamid produced devastating effects, noted at stations PW-9.2 and PWE-11.4 in insignificant catches of fish.

Bottom Fauna

The bottom fauna, because of its varied, sensitive and fixed nature, represents one of the most useful groups in assessment of water quality.

The bottom fauna found at stations PW-42.9, PW-35.2 and PW-27.0 may be considered typical of unpolluted waters of the Welland River and may be compared with the lower stations. Small differences among stations were considered to be possibly due to sampling or naturally occurring succession. Gross differences in species-composition and standing crops are due to altered quality of waters and sediments.

The absence of mayflies, crayfish and certain midges and the greater numbers of annelids at station PW-21.2 indicated mild pollution just upstream from Welland. The large increase, at least 25 times, in bottom fauna and the reduction in the number of species of tolerant annelids indicated excessive organic enrichment at station PW-16.2. Station PW-13.2 was similar to PW-16.2, but the reduced standing crop indicated less enrichment at that point.

The presence of only two species of bottom fauna, each with low standing crops, indicated toxic pollution at station PW-9.2. A greater bottom fauna population would be expected there, particularly considering the effects of organic enrichment from the City of Welland. Discharges from the plant to the main river and Thompson's Creek are high in ammonia. This toxic pollution load probably seriously impedes natural purification processes in the sediments through a reduction in the bottom fauna.

Zooplankton

The volume of plankton was great at stations PW-42.9, PW-35.2 and PW-27.0, depressed at PW-21.2 and very low at all of the downstream stations.

The depression of the standing crop of plankton at station PW-21.2 to one-tenth of the crops upstream may be a result of the much greater population of minnows at that point. Predation by minnows, however, would not explain the very low volumes below Welland except possibly at stations PW-13.2 and PWEL-12.0. Impaired water quality would appear to be responsible for the low populations of zooplankton especially at stations PW-16.2, PW-9.2 and PWE-11.4.

Plant Communities

- Rooted Aquatics and Filamentous Algae

The upper Welland River is characterized by an abundance of emergent aquatics, but a limited development of submergent aquatics. At station PW-42.9 submergents were common to a depth of about three feet, but at stations PW-35.2, PW-27.0, PW-21.2, submergents were very sparse. Emergent and floating aquatics were common throughout, and the filamentous algae, Cladophora, was common at station PW-21.2. At station PW-16.2 submergent aquatics were abundant to a depth of 5 feet, forming a heavily vegetated zone about 12 feet wide along each bank. Filamentous algae were observed growing throughout the pondweeds and beyond them to a depth of about 6 feet.

The peak in abundance of rooted submergents and filamentous algae occurred at a point midway between stations PW-16.2 and PW-13.2. Water lilies and submergent aquatics were absent at station PW-9.2 while streamside vegetation was extremely luxuriant. Station PWE-11.4 was similar to PW-9.2.

- Phytoplankton

Thirty-one genera of planktonic algae were observed in samples collected in July. Green algae predominated with 18 genera, while blue-green algae and diatoms were represented by four and six genera respectively.

Populations of planktonic algae were low throughout the Welland River except below the Cyanamid plant, where a large number of genera made up a very dense popula-

tion. A reduction in the number of genera and standing crop of algae was evident below Welland. All of the common genera taken below Welland are known for tolerance to pollution. Several genera possibly intolerant to pollution, which were common above the city were absent below Welland. At Port Robinson, some improvement was indicated by a greater variety of algae.

A total of 24 genera of algae was established for samples taken below the Cyanamid plant. Several forms not noted for their tolerance to pollution were common. Apparently the levels of ammonia did not impede the development of a varied and abundant population, and, in fact, together with a level of phosphorus, appeared to have promoted algae growth.

(b) <u>Lyon's Creek</u>

In its head waters in the city, Lyon's Creek is an intermittent stream. During summer months essentially the entire flow consists of sewage from the Bradley Street pumping station and the overflow from the Welland Tubes Ltd. waste treatment lagoon. In this section of the stream, the creek bed was smothered with a coating of reddish brown sediment. An oily odour was prevalent and objectionable floating solids were observed.

The four water quality sampling stations on Lyon's Creek are show in Figure 3-1.

<u>Biochemical Oxygen Demand (5-Day)</u>

The organic loading contributed by the City of Welland was reflected in the BOD concentrations at stations PWEL-24.2 and PWEL-23.2 where levels were well above the limit of 4.0 ppm throughout the six month survey. At PWEL-19.6, BOD levels were also high during the summer months.

<u>Dissolved Oxygen</u>

Upstream from the Bradley Street pumping station at PWEL-24.2, excessive algae growths resulted in supersaturation of dissolved oxygen during the July and September surveys. At station PWEL-23.2, below the Welland Tubes Ltd. lagoon outfall, oxygen depletion to an average of 17% saturation was observed in July

Downstream at Cooks Mills, PWEL-19.6, D.O. levels were satisfactory; however, conditions worsened at

PWEL-16.8 where water quality was influenced by polluted backwater.

Nitrogens

At the three upstream stations, free ammonia and total Kjeldahl levels were high throughout the survey, with the concentrations at PWEL-23.2 and PWEL-19.6 being toxic.

Phosphorus

The four stations on Lyon's creek showed high phosphorus concentrations throughout the survey. A slight reduction in phosphorus levels at PWEL-16.8 was probably due to deposition and dilution.

Phenol

The phenol concentrations exceeded the objectives at all four stations on Lyon's Creek. This pollution is caused primarily by discharges from the Welland Tubes Ltd. and Page Hersey Tubes Ltd.

Iron

The iron concentrations exceeded the objective at all four stations on Lyon's Creek. A notable increase occurred below the Welland Tubes Ltd. outfall at PWEL-23.2 where iron concentration reached 8.46 ppm in September, 1964. A reduction to more tolerable limits at PWEL-16.8 was attributed to dilution water from the Niagara River.

Solids

Suspended solids were high at the three upstream stations in Lyon's Creek throughout the survey. Conditions improved in the slow-moving lower portion of the stream.

Total Coliform Organisms

The coliform densities at PWEL-24.2 and PWEL-23.2 were very high and characteristic of raw sewage. A rapid death rate, however, was indicated by improved conditions at station PWEL-19.6.

Biological Findings

Fish Populations

Station PWEL-12.0, with its varied and abundant fish population, (listed in Appendix 2, Table 7-2) is not seriously affected by the Cyanamid of Canada Ltd. (Welland Works) wastes and serves well for comparison purposes. In fact, the large population in Lyon's Creek at Station PWEL-12.0 may have been augmented by fish escaping from the lower Welland when the flow of the Niagara River water to feed the power canal was terminated in the spring.

Bottom Fauna

A moderately polluted condition is indicated in the lower portion of Lyon's Creek below the Queen Elizabeth Way. Midges and annelids pre-dominated, while mayflies, amphipods and isopods were absent. Some organic enrichment was evident.

Plant Communities

A moderate amount of submerged vegetation was present at station PWEL-12.0 in association with the algae.

3. DISCUSSION OF SURVEY RESULTS

High BOD, nitrogen and phosphorus levels as well as excessive coliform counts and low D.O. concentrations in the Welland River and Lyon's Creek in the vicinity of Welland indicate gross pollution conditions in these stream. High values for such parameters as iron and phenol are indicative of industrial waste pollution in the same sections of the streams. Changes in fish species and population, bottom fauna and aquatic plants further demonstrate the serious impairment of water quality.

Below Port Robinson, elevated free ammonia and organic nitrogen levels were the result of ammonia wastes being discharged to the river by Cyanamid of Canada Ltd. (Welland Works). Sharp decreases in fish populations, bottom fauna and zooplankton indicate the toxic nature of these wastes.

Elevated BOD and nitrogen levels and increased coliform densities in the last four mile reach of the Welland River denote the degradation in water quality caused by the discharge of wastes from the City of Niagara Falls Stanley Road settling tank.

Dissolved oxygen concentrations taken monthly at each station reveal that critical quality conditions prevailed during the July survey.

The adverse qualitative conditions that prevailed during the survey reflect the need for reduction of the amount of polluting material discharged to the river and additional dilution water. These measures are imperative for the maintenance of satisfactory water quality in the lower river.

CHAPTER VI

CONCLUSIONS

1. Water quality in the upper portion of the Welland River is reasonably good as indicated by satisfactory chemical and bacteriological characteristics as well as the presence of as great a variety of species of aquatic organisms as could be expected in a slow-moving, turbid stream.

2. Serious conditions of pollution related to domestic sewage and industrial waste discharges from the City of Welland were demonstrated in the lower Welland River for a distance of eight miles.

3. The toxic effects of wastes from Cyanamid of Canada Ltd. (Welland Works) on most forms of river life was clearly indicated.

3a. Lyon's Creek showed extreme degradation by wastes discharged from the Bradley Street pumping station and the Welland Tubes Ltd. effluent.

4. Without the addition of dilution water, the dissolved oxygen content of the Welland River in the city would fall below desirable limits and intolerable conditions would result.

5. For flow augmentation and maintenance of natural self-purification processes in the lower river, diversion of 170 cfs from the Welland Ship Canal should be continued at the Welland filtration plant until secondary wastewater treatment is provided.

6. Secondary treatment of all wastes from Welland is required to safeguard the water quality of the Welland River.

7. Treatment of Cyanamid of Canada Ltd. wastes to a degree equivalent to secondary sewage treatment should be provided as well as removal of ammonia compounds to reduce the river ammonia level below 2.0 ppm.

8. The effluent from the City of Niagara Falls Stanley Road settling tank was responsible for pollution of the Welland River near its mouth.

CHAPTER VII

APPENDIX 1

WELLAND RIVER SURVEY

CHEMICAL, PHYSICAL AND BACTERIOLOGICAL DATA

JUNE - NOVEMBER

1964

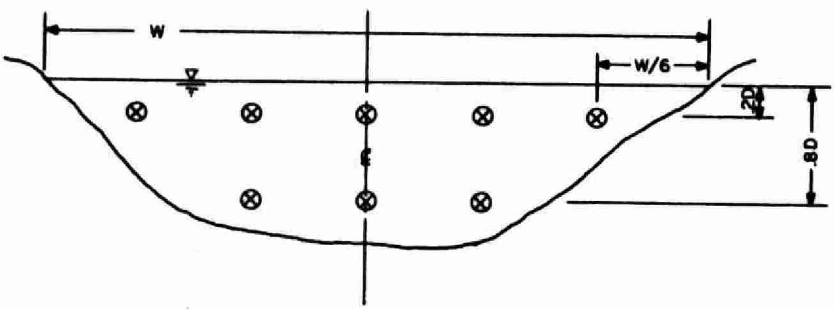
Sampling Procedure

During the June investigation, eight locations were sampled at each range to determine if quality impairment was stratified either vertically or horizontally in the stream cross-sections. The stations were shown in Figure 7-1.

Figure 7-1

Welland River Survey

Typical Sampling Range - June

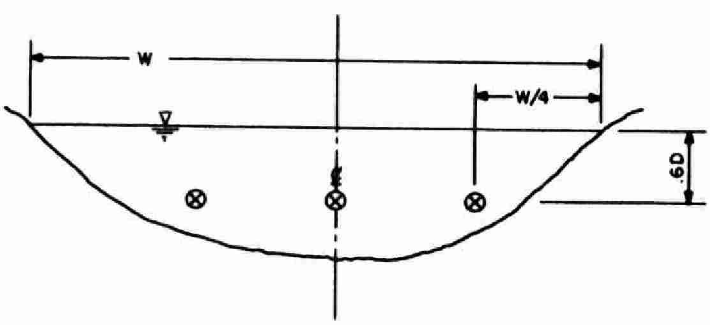


When very little fluctuation in depth samples was observed, the sampling stations were reduced to three per section as shown in Figure 7-2.

Figure 7-2

Welland River Survey

Typical Sampling Range - July, November



WELLAND RIVER SURVEY - 1964

RANGE: PW 27.0

NOTE: ALL VALUES ARE MONTHLY AVERAGES

	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.
D. O. (ppm)	5.84	4.5	4.2	6.2	8.6	12.6
D.O. % sat.	65.8	54.6	48.6	64.6	76.0	96.3
TEMP. °C	21.86	24.3	23.0	17.8	10.0	2.5
BOD (ppm)	1.6	1.6	3.2	2.5	1.6	1.4
TOTAL SOLIDS (ppm)	375	392	482	354	337	299
SUSP. SOLIDS (ppm)	--	55	121	73	59	35
TURBID-ITY	79	0	--	207	100	44
FREE AMMONIA (ppm)	.30	.16	.11	.05	.29	.20
TOTAL KJELDAHL (ppm)	1.5	1.2	1.9	1.3	1.3	1.0
NITRITE (ppm)	.01	tr.	tr.	0	.35	tr.
NITRATE (ppm)	--	5	0	tr.	tr.	tr.
SOLUBLE PHOS. (ppm)	.2	--	--	.21	1.2	.38
TOTAL PHOS. (ppm)	1.04	--	1.1	.89	1.4	.47
IRON (ppm)	3.1	3.4	--	7.72	5.2	3.1
PHENOL (ppm)	19	--	33	3.2	2	6.3
M.F. COLIFORM (per 100 ml.)	978	223	833	1733	800	933
APPARENT COLOUR	235	--	170	--	--	133

WELLAND RIVER SURVEY - 1964

RANGE: PW 22.9

NOTE: ALL VALUES ARE MONTHLY AVERAGES

	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.
D. O. (ppm)	5.2	4.5	6.6	5.9	8.9	12.7
D.O. % sat.	57.2	50.2	75.5	59.6	79.3	92.0
TEMP. °C	21.0	24.8	22.6	17.0	10.0	1.8
BOD (ppm)	1.7	1.8	3.7	3.1	2.3	2.7
TOTAL SOLIDS (ppm)	494	419	426	404	339	330
SUSP. SOLIDS (ppm)	142	111	97	111	47	49
TURBID-ITY	180	--	65	193	93	48
FREE AMMONIA (ppm)	0.70	0.38	0.1	.07	.26	0.7
TOTAL KJELDAHL (ppm)	2.0	1.3	2.6	1.3	1.7	1.9
NITRITE (ppm)	0.02	tr.	.003	0	1.1	tr.
NITRATE (ppm)	.36	0.18	--	tr.	0.01	0.3
SOLUBLE PHOS. (ppm)	0.4	--	--	.33	1.1	.76
TOTAL PHOS. (ppm)	2.3	--	.83	1.09	1.1	.78
IRON (ppm)	6.2	4.2	--	10.2	4.0	3.4
PHENOL (ppm)	7.9	0	6.3	2	3	0
M.F. COLIFORM (per 100 ml.)	8040	3766	6400	2600	1600	3033
APPARENT COLOUR	5	5	5	5	5	5

WELLAND RIVER SURVEY — 1964

RANGE: PW 18.6

NOTE: ALL VALUES ARE MONTHLY AVERAGES

	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.
D.O. (ppm)	6.1	3.9	4.0	3.6	7.8	11.5
D.O. % sat.	62	46	46	37.3	73	91
TEMP. °C	17.3	24.2	22.7	17.6	13.0	5.3
BOD (ppm)	2.3	2.2	2.1	1.8	3.3	3.1
TOTAL SOLIDS (ppm)	261	315	264	304	237	226
SUSP. SOLIDS (ppm)	21	89	49	61	14	27
TURBIDITY	15.1	--	--	45	24	23
FREE AMMONIA (ppm)	.36	.51	.23	.62	.49	0.30
TOTAL KJELDAHL (ppm)	1.4	1.1	3.3	1.4	1.26	1.03
NITRITE (ppm)	0.01	0.01	0.01	0.02	0.01	tr.
NITRATE (ppm)	.3	.2	--	.8	.30	0
SOLUBLE PHOS. (ppm)	.28	--	--	.24	.34	.39
TOTAL PHOS. (ppm)	.66	--	.57	.78	.55	.51
IRON (ppm)	1.09	1.93	--	2.67	1.01	.78
PHENOL (ppm)	7	1.3	2*	1.3	6	5
M.F. COLIFORM (per 100 ml.)	34166	66000	37466	15333	74333	52333
APPARENT COLOUR	16.6	--	41.6	--	--	11.6

Note: During this time only one sample per month was taken.

WELLAND RIVER SURVEY - 1964

RANGE: DIVERSION

NOTE: ALL VALUES ARE MONTHLY AVERAGES

	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.
D.O. (ppm)		9.4	7.8	8.8	10.4	12.4
D.O. % sat.		95	89	96	100	95
TEMP. °C		17.0	22.0	20	14.0	4.5
BOD (ppm)		0.8	0.9	1.3	1.1	2.4
TOTAL SOLIDS (ppm)		224	238	224	212	256
SUSP. SOLIDS (ppm)		18	20	20	11	51
TURBIDITY				10.5	13.5	31.0
FREE AMMONIA (ppm)		.03	0.0	0.05	0.05	tr.
TOTAL KJELDAHL (ppm)		0.64	0.52	--	1.1	0.6
NITRITE (ppm)		0	0	--	tr.	tr.
NITRATE (ppm)		--	--	--	0.0	0
SOLUBLE PHOS. (ppm)				.12	--	0.36
TOTAL PHOS. (ppm)		0.12	--	0.24	4.96	0.42
IRON (ppm)		.56		0.72	0.55	--
PHENOL (ppm)		7	0	0	--	4
M.F. COLIFORM (per 100 ml.)		1800	580	230	560	470
APPARENT COLOUR			less than 5			20

WELLAND RIVER SURVEY – 1964

RANGE: PW 18.2

NOTE: ALL VALUES ARE MONTHLY AVERAGES

	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.
D.O. (ppm)	5.95	5.03	4.6	6.0	8.7	11.1
D.O. % sat.	61	56	53	62.6	84	86
TEMP. °C	17.6	21.6	22.8	18.0	14.0	4.5
BOD (ppm)	1.8	1.5	2.4	2.8	3.1	3.6
TOTAL SOLIDS (ppm)	287	251	324	259	219	252
SUSP. SOLIDS (ppm)	18	25	43	39	12	45
TURBIDITY	23.8	--	45	31.7	23	20.7
FREE AMMONIA (ppm)	.76	.19	0.0	.54	.40	.60
TOTAL KJELDAHL (ppm)	1.5	.52	3.4	1.08	.95	1.6
NITRITE (ppm)	.01	tr.	.01	.02	.01	tr.
NITRATE (ppm)	.33	--	0	.62	tr.	0
SOLUBLE PHOS. (ppm)	.47	--	--	.26	.73	.51
TOTAL PHOS. (ppm)	1.08	--	.68	.57	.60	.86
IRON (ppm)	1.66	1.05	--	1.86	.75	1.22
PHENOL (ppm)	7	--	4.3	2.	7.3	11.3
M.F. COLIFORM (per 100 ml.)	43120	19933	68333	92966	203666	61666
APPARENT COLOUR	20.6	--	5	--	--	15

WELLAND RIVER SURVEY — 1964

RANGE: PW 17.4

NOTE: ALL VALUES ARE MONTHLY AVERAGES

	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.
D.O. (ppm)	6.0	3.1	5.2	4.5	7.3	12.5
D.O. % sat.	66	38	59	48	72	97
TEMP. °C	21	22	23.2	19.8	15.3	6.26
BOD (ppm)	1.7	1.6	1.9	2.4	4.1	3.7
TOTAL SOLIDS (ppm)	285	250	306	286	239	341
SUSP. SOLIDS (ppm)	28	17	34	37	23	33
TURBIDITY	27	--	--	38	29	16
FREE AMMONIA (ppm)	1.04	.58	0	.62	.45	.26
TOTAL KJELDAHL (ppm)	2.4	.98	2.8	1.4	1.56	.76
NITRITE (ppm)	.04	0.01	.01	.02	.04	tr.
NITRATE (ppm)	1.0	--	0.4	1.35	3.8	0.16
SOLUBLE PHOS. (ppm)	.08	--	--	.31	.45	3.5
TOTAL PHOS. (ppm)	.97	--	.66	.71	.59	.73
IRON (ppm)	4.07	1.3	--	2.23	1.58	.97
PHENOL (ppm)	9.5	8.3	8.3	2.	6.3	2.
M.F. COLIFORM (per 100 ml.)	79000	89000	51600	50930	73000	93000
APPARENT COLOUR	40	--	33.3	--	--	30

WELLAND RIVER SURVEY – 1964

RANGE: PW 16.2

NOTE: ALL VALUES ARE MONTHLY AVERAGES

	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.
D.O. (ppm)		3.5	4.9	5.3	7.7	11.3
D.O. % sat.		39	57	56	74	89
TEMP. °C		22.3	22.6	19.2	14.2	5.5
BOD (ppm)		1.3	1.9	3.2	3.7	2.7
TOTAL SOLIDS (ppm)		249	310	273	234	235
SUSP. SOLIDS (ppm)		26	41	45	12	31
TURBIDITY		--	34	38	24	19
FREE AMMONIA (ppm)		.64	0	.47	.41	.30
TOTAL KJELDAHL (ppm)		.98	1.07	1.2	.93	1.0
NITRITE (ppm)		.01	.01	.02	.04	.01
NITRATE (ppm)		.2	tr.	.7	.82	.2
SOLUBLE PHOS. (ppm)		--	--	.3	.32	.22
TOTAL PHOS. (ppm)		--	--	.58	.52	.56
IRON (ppm)		1.34	--	1.74	1.02	1.0
PHENOL (ppm)		3	5	2	5	5
M.F. COLIFORM (per 100 ml.)		6533	15000	16566	28000	45000
APPARENT COLOUR		--	33.3	--	--	15

WELLAND RIVER SURVEY - 1964

RANGE: PW 15.2

NOTE: ALL VALUES ARE MONTHLY AVERAGES

	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.
D. O. (ppm)		3.8	5.4	4.8	7.2	10.3
D.O. % sat.		40	64	52	71	83
TEMP. °C		22.6	23.8	19.5	15.0	6.0
BOD (ppm)		1.3	1.7	3.3	4.5	3.2
TOTAL SOLIDS (ppm)		246	281	236	221	238
SUSP. SOLIDS (ppm)		13	31	43	16	20
TURBID-ITY		--	33	36	23	19
FREE AMMONIA (ppm)		.51	0	.46	.52	.6
TOTAL KJELDAHL (ppm)		.91	.87	1.3	1.2	1.3
NITRITE (ppm)		.01	.01	.03	.03	.02
NITRATE (ppm)		.25	0	.85	.95	.5
SOLUBLE PHOS. (ppm)		--	--	.22	.3	.25
TOTAL PHOS. (ppm)		--	--	.32	1.31	.77
IRON (ppm)		1.12	--	1.51	.95	1.25
PHENOL (ppm)		2.	.6	.6	8.	1.3
M.F. COLIFORM (per 100 ml.)		4660	9300	21000	32000	45000
APPARENT COLOUR		--	28	--	--	18

WELLAND RIVER SURVEY – 1964

RANGE: PW 14.6

NOTE: ALL VALUES ARE MONTHLY AVERAGES

	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.
D.O. (ppm)	7.02	4.2	4.6	5.3	7.1	11.1
D.O. % sat.	78	48	54	56	75	88
TEMP. °C	21.2	23.0	24.0	19.5	14.0	5.5
BOD (ppm)	1.54	1.2	1.8	1.9	2.6	3.5
TOTAL SOLIDS (ppm)	266	269	280	273	243	228
SUSP. SOLIDS (ppm)	17	31	28	35	12	19
TURBIDITY	13.2	--	--	29	23	19
FREE AMMONIA (ppm)	.36	.58	0	.37	.46	.30
TOTAL KJELDAHL (ppm)	1.5	1.2	.94	.95	1.2	1.03
NITRITE (ppm)	.02	.02	.01	.02	.04	.01
NITRATE (ppm)	.3	.34	--	.73	.58	.3
SOLUBLE PHOS. (ppm)	.25	--	--	.21	.37	.25
TOTAL PHOS. (ppm)	3.9	.34	.51	.35	.45	.57
IRON (ppm)	1.02	1.38	--	1.66	.99	.97
PHENOL (ppm)	9	5	8	0	12	5
M.F. COLIFORM (per 100 ml.)	3300	5100	2500	3440	111300	36000
APPARENT COLOUR	13	--	25	--	--	13.3

WELLAND RIVER SURVEY - 1964

RANGE: PW-10.0

NOTE: ALL VALUES ARE MONTHLY AVERAGES

	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.
D.O. (ppm)		7.1	5.9	5.9	10.6	10.0
D.O. % sat.		84	69	64	102	79
TEMP. °C		25.3	24.5	19.5	14.4	5.2
BOD (ppm)		3.3	2.9	2.4	5.1	2.1
TOTAL SOLIDS (ppm)		217	306	247	313	232
SUSP. SOLIDS (ppm)		26	47	31	7	12
TURBIDITY		--	9.0	35	19.8	--
FREE AMMONIA (ppm)		1.3	7.3	.28	36.7	8.1
TOTAL KJELDAHL (ppm)		2.2	11.8	1.1	49.3	11.4
NITRITE (ppm)		.02	.01	.02	.08	.01
NITRATE (ppm)		0.16	.45	.2	14.2	tr.
SOLUBLE PHOS. (ppm)		--	--	.22	--	.36
TOTAL PHOS. (ppm)		--	2.44	.33	1.73	.49
IRON (ppm)		.95	--	2.09	.64	.61
PHENOL (ppm)		2.	7	.66	4	2.
M.F. COLIFORM (per 100 ml.)		1310	600	780	20	12320
APPARENT COLOUR		--	--	--	--	8

WELLAND RIVER SURVEY - 1964

RANGE: PW 9.2

NOTE: ALL VALUES ARE MONTHLY AVERAGES

	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.
D.O. (ppm)	11.4	8.6	10.1	5.7	11.1	10.6
D.O. % sat.	127	102	119	62	106	85
TEMP. °C	21.7	25.5	24.2	19.5	13.5	6.0
BOD (ppm)	3.4	4.3	3.0	6.1	4.8	8.8
TOTAL SOLIDS (ppm)	302	356	336	313	280	151
SUSP. SOLIDS (ppm)	15	20	20	22	13	8
TURBID-ITY	10.1	--	4.8	13.5	13.4	--
FREE AMMONIA (ppm)	17.4	5.7	36.6	16.5	18.0	6.6
TOTAL KJELDAHL (ppm)	24	19.0	43.0	43.0	29.8	13.4
NITRITE (ppm)	.05	.02	.015	--	.71	tr.
NITRATE (ppm)	.4	--	10.0	6.3	2.67	2.05
SOLUBLE PHOS. (ppm)	1.5	--	--	2.8	.68	1.2
TOTAL PHOS. (ppm)	1.5	.5	1.7	3.0	.78	.65
IRON (ppm)	.62	--	--	1.42	.86	.50
PHENOL (ppm)	6	4	7	3	7	2
M.F. COLIFORM (per 100 ml.)	45	2700	5730	380	60	580
APPARENT COLOUR	20	--	25	--	--	--

WELLAND RIVER SURVEY — 1964

RANGE: PWE 11.4

NOTE: ALL VALUES ARE MONTHLY AVERAGES

	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.
D.O. (ppm)				5.9		
D.O. % sat.				63		
TEMP. °C				19.0		
BOD (ppm)				13.0		
TOTAL SOLIDS (ppm)				296		
SUSP. SOLIDS (ppm)				16		
TURBID-ITY				9.7		
FREE AMMONIA (ppm)				7.3		
TOTAL KJELDAHL (ppm)				21.0		
NITRITE (ppm)				.4		
NITRATE (ppm)				2.2		
SOLUBLE PHOS. (ppm)				2.9		
TOTAL PHOS. (ppm)				3.3		
IRON (ppm)				1.05		
PHENOL (ppm)				3		
M.F. COLIFORM (per 100 ml.)				90000		
APPARENT COLOUR						

WELLAND RIVER SURVEY — 1964

RANGE: PWE 12.8

NOTE: ALL VALUES ARE MONTHLY AVERAGES

	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.
D.O. (ppm)				6.7	6.6	11.3
D.O. % sat.				73	64	93
TEMP. °C				20	14.4	7.0
BOD (ppm)				5.5	3.1	3.6
TOTAL SOLIDS (ppm)				224	310	219
SUSP. SOLIDS (ppm)				14	7	14
TURBIDITY				7.8	10.0	--
FREE AMMONIA (ppm)				1.08	23.5	.04
TOTAL KJELDAHL (ppm)				21.1	32.0	1.03
NITRITE (ppm)				--	.203	tr.
NITRATE (ppm)				.92	6.0	0
SOLUBLE PHOS. (ppm)				1.34	--	.08
TOTAL PHOS. (ppm)				1.55	4.8	.12
IRON (ppm)				.65	.46	.57
PHENOL (ppm)				3	12	2
M.F. COLIFORM (per 100 ml.)				17300	4530	550
APPARENT COLOUR						

WELLAND RIVER SURVEY - 1964

RANGE: PWEL 24.2

NOTE: ALL VALUES ARE MONTHLY AVERAGES

	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.
D.O. (ppm)		10.9	--	19.7	14.7	9.7
D.O. % sat.		134	--	155	73.5	74.5
TEMP. °C		27.0	--	19.0	11.0	4.3
BOD (ppm)			10.5	--	5.8	7.7
TOTAL SOLIDS (ppm)			417	--	363	352
SUSP. SOLIDS (ppm)			--	--	27	18
TURBIDITY			35	31	40	31
FREE AMMONIA (ppm)			.49	1.0	1.3	3.05
TOTAL KJELDAHL (ppm)			4.4	8.3	7.45	5.05
NITRITE (ppm)			.03	.015	.015	.01
NITRATE (ppm)			0	tr.	.65	tr.
SOLUBLE PHOS. (ppm)			--	.18	.7	.425
TOTAL PHOS. (ppm)			--	1.26	7.4	1.21
IRON (ppm)			5.8	2.22	7.55	3.72
PHENOL (ppm)			3.5	8.5	4	25.0
M.F. COLIFORM (per 100 ml.)			195000	118000	49500	68000
APPARENT COLOUR			--	--	115	35

WELLAND RIVER SURVEY — 1964

RANGE: PWEL 23.2

NOTE: ALL VALUES ARE MONTHLY AVERAGES

	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.
D.O. (ppm)		.54	--	1.3	2.7	1.6
D.O. % sat.		6.3	--	17	24	14
TEMP. °C		26.5	--	19.0	17.3	10.0
BOD (ppm)			14.7	13.6	8.1	16.0
TOTAL SOLIDS (ppm)			305	363	261	371
SUSP. SOLIDS (ppm)			--	39	16	35
TURBIDITY			26	46	33.3	74
FREE AMMONIA (ppm)			3.2	3.2	3.7	3.9
TOTAL KJELDAHL (ppm)			6.0	5.0	4.5	4.4
NITRITE (ppm)			0	tr.	.01	.01
NITRATE (ppm)			0	0	.12	0
SOLUBLE PHOS. (ppm)			--	1.36	--	.07
TOTAL PHOS. (ppm)			--	2.98	4.6	.98
IRON (ppm)			5.55	8.40	3.8	8.03
PHENOL (ppm)			3.3	12	9	7
M.F. COLIFORM (per 100 ml.)			983000	10346000	1186000	606000
APPARENT COLOUR			--	--	--	138

WELLAND RIVER SURVEY — 1964

RANGE: PWEL 19.6

NOTE: ALL VALUES ARE MONTHLY AVERAGES

	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.
D.O. (ppm)		12.9	--	8.8	8.5	9.1
D.O. % sat.		157	--	92	68	67.5
TEMP. °C		26.0	--	18.0	11.75	3.25
BOD (ppm)		--	6.4	34.5	2.7	4.7
TOTAL SOLIDS (ppm)			369	389	300	316
SUSP. SOLIDS (ppm)			--	84	45	55
TURBIDITY			10	35	13.5	11.25
FREE AMMONIA (ppm)			.35	.1	4.3	5.25
TOTAL KJELDAHL (ppm)			3.0	4.9	5.9	6.0
NITRITE (ppm)			.03	.02	.04	tr.
NITRATE (ppm)			0	tr.	.31	tr.
SOLUBLE PHOS. (ppm)			--	.22	--	.18
TOTAL PHOS. (ppm)			--	1.34	.47	.52
IRON (ppm)			1.09	2.32	1.11	1.76
PHENOL (ppm)			3	6	12.5	10
M.F. COLIFORM (per 100 ml.)			450	600	665	3930
APPARENT COLOUR			--	--	--	2.75

WELLAND RIVER SURVEY - 1964

Note: During this time only, one reading was taken each month.

RANGE: PWEL 16.8

NOTE: ALL VALUES ARE MONTHLY AVERAGES

	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.
D.O. (ppm)			--	2.8	4.0	7.1
D.O. % sat.			--	22	35	51
TEMP. °C			--	15.0	11.0	2.0
BOD (ppm)			1.6	2.4	2.0	2.2
TOTAL SOLIDS (ppm)			408	322	342	332
SUSP. SOLIDS (ppm)			--	5	3	1
TURBIDITY			17.0	4.0	3.3	--
FREE AMMONIA (ppm)			.32	.20	--	.90
TOTAL KJELDAHL (ppm)			.91	.70	--	1.1
NITRITE (ppm)			0	0	--	tr.
NITRATE (ppm)			0	0	0	1.25
SOLUBLE PHOS. (ppm)			--	.64	--	--
TOTAL PHOS. (ppm)			--	.96	0.50	--
IRON (ppm)			.46	.65	.49	.36
PHENOL (ppm)			2.0	12.0	0	2.0
M.F. COLIFORM (per 100 ml.)			180	260	110	130
APPARENT COLOUR			5			less than 5

APPENDIX 2

WELLAND RIVER SURVEY

BIOLOGICAL DATA

JUNE 1964

TABLE 7-2

Catch of Fish from Nine Stations

on the Welland River

June 1964

Species	Stations 1	2	3	4	5	6	7	8	9
White sucker								2	1
Carp		2		5	6	4			2
Golden shiner	5	5	1	3		32			
Creek chub									1
Emerald shiner		1	1	3					72
Spottail shiner				16		1		2	197
Bluntnose minnow		7	5	57	1	2			1
Brown bullhead	18	16	7	33	1	11	1		60
Tadpole madtom	3	2	2						1
Mudminnow			1						
Northern pike	3	3			1				
Killifish					1				
Rock bass									1
Pumpkinseed	3	23	12	10					3
White crappie	11	2	2	6					
Black crappie	10	11	4	7					
Yellow perch	1	8	2	11		3		1	2
Johnny darter				1					
Number seine hauls	5	5	4	4	1	3	4	4	4

TABLE 7-3

Number of Individuals of Each Genera of Bottom Fauna

in Each Ekman-dredge Collection - Welland River

June 1964

	Station 1						Station 2					
Genus	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Oligochaets												
Limnodrilus	3				1	4	3	3	1		1	
Tubifex												
Lumbriculus												
Leeches												
Erpobdella												
Amphipods												
Gammarus			14				6			2		
Isopods												
Asellus	1		16		2		3	1				
Mayflies												
Hexagenia	4	1					1	1	2			
Caenis		2	1									1

Genus	Station 1						Station 2					
	1	2	3	4	5	6	1	2	3	4	5	6
Alderfiles												
Sialis												
Beetles												
Dubiraphia			1	1		1						
Helophorus												
Flies												
Chaoborus				1	1			1	2			
Palpomyia								4			1	
Procladius			1			1	3	2	6	1		2
Anatopynia												
Chironomus								2	5		1	
Cryptochironomus	1		2			1			1			
Glyptotendipes							1					
Tanytarsus			2									
Polypedilum			4			2		1				
Calopsectra												
Tipula								1				
Mites												
Hydrachna				1								

Genus	Station 1						Station 2					
	1	2	3	4	5	6	1	2	3	4	5	6
Molluscs												
Margaritifera					1							
Valvata												
Campelloma												
Sphaerium	3	1			2	2						5
Pisidium												
Total Number	12	3	41	3	7	11	19	16	24	3	3	8
Total Weight (gms.)	.21	.03	.08	.01	.15	.04	.09	.07	.07	.01	.01	.07

TABLE 7-3

Number of Individuals of Each Genera of Bottom Fauna

in Each Ekman-dredge Collection - Welland River

June 1964

Genus	Station 3						Station 4					
	1	2	3	4	5	6	1	2	3	4	5	6
Oligochaets												
Limnodrilus		1			1		3	22	7	17	9	14
Tubifex												
Lumbriculus												
Leeches												
Erpobdella												
Amphipods												
Gammarus	1	1	1		1		2					
Isopods												
Asellus	1				1		1					
Mayflies												
Hexagenia												
Caenis	1											

Genus	Station 3						Station 4					
	1	2	3	4	5	6	1	2	3	4	5	6
Alderflies												
Sialis												
Beetles												
Dubiraphia			1									
Helophorus												
Flies												
Chaoborus												
Palpomyia				2								
Procladius		1									1	1
Anatopynia									1			
Chironomus												
Cryptochironomus		1		1								
Glyptotendipes			6		1							
Tanytarsus												
Polypedilum		5			1							
Calopsectra									1			
Tipula												
Mites												
Hydrachna												

Genus	Station 3						Station 4					
	1	2	3	4	5	6	1	2	3	4	5	6
Molluscs												
Margaritifera												
Valvata												
Campelloma												
Sphaerium				1	2				2	1		
Pisidium												
Total Number	3	9	8	4	5	2	6	22	11	19	10	14
Total Weight (gms.)	.01	.03	.06	.07	.02	.01	.03	.11	.03	.06	.03	.06

TABLE 7-3

Number of Individuals of Each Genera of Bottom Fauna

in Each Ekman-dredge Collection - Welland River

June 1964

Genus	Station 5			Station 6			Station 7					
	1	2	3	1	2	3	1	2	3	4	5	6
Oligochaets												
Limnodrilus	181	170	192	48	150	290		2	13		7	10
Tubifex	10	8	12									
Lumbriculus												
Leeches												
Gammarus												
Isopods												
Asellus												
Mayflies												
Hexagenia												
Caenis												

Genus	Station 5			Station 6			Station 7					
	1	2	3	1	2	3	1	2	3	4	5	6
Alderflies												
Sialis												
Beetles												
Dubiraphia												
Helophorus				3								
Flies												
Chaoborus												
Palpomyia												
Procladius		2	1	1	1	1	2	48	2	5	6	4
Anatopynia												
Chironomus												
Cryptochironomus												
Glyptotendipes												
Tanytarsus												
Polypedilum												
Calopsectra												
Tipula												
Mites												
Hydrachna												

Genus	Station 5			Station 6			Station 7					
	1	2	3	1	2	3	1	2	3	4	5	6
Molluscs												
Margaritifera												
Valvata		2	1			18						
Campelloma	1											
Sphaerium						1						
Pisidium	2											
Total Number	194	182	206	52	151	310	2	50	15	5	13	14
Total Weight (gms.)	1.60	1.35	1.65	.23	.60	1.15	.01	.07	.10	.02	.06	.11

TABLE 7-3

Number of Individuals of Each Genera of Bottom Fauna

in Each Ekman-dredge Collection - Welland River

June 1964

Genus	Station 8						Station 9					
	1	2	3	4	5	6	1	2	3	4	5	6
Oligochaets												
Limnodrilus	10	13	15	13	18	2	3	8	8			
Tubifex	4	1	2	10	1	4		1	3			
Lumbriculus		3	1	1								
Leeches												
Erpobdella		1	1									
Amphipods												
Gammarus												
Isopods												
Asellus												
Mayflies												
Hexagenia												
Caenis												

Genus	Station 8						Station 9					
	1	2	3	4	5	6	1	2	3	4	5	6
Alderflies												
Sialis							1					
Beetles												
Dubiraphia												
Helophorus												
Flies												
Chaoborus												
Palpomyia							1	2				
Procladius	6	11	10	7	1	3			1			
Anatopynia												
Chironomus		2	3			1						
Cryptochironomus				1				1				
Glyptotendipes												
Tanytarsus												
Polypedilum			1	2	1		1	1	9			
Calopsectra							1	1				
Tipula												
Mites												
Hydrachna												

Genus	Station 8						Station 9					
	1	2	3	4	5	6	1	2	3	4	5	6
Molluscs												
Margaritifera												
Valvata												
Campelloma												
Sphaerium	5	1	2	10	6	8	3	2				
Pisidium	1	1		9	5							
Total Number	26	33	35	53	32	15	10	16	21			
Total Weight (gms.)	.41	.39	.75	.84	.92	.60	.47	.07	.04			

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ABBREVIATIONS

BOD	- biochemical oxygen demand
^{o}C.	- degrees Centigrade
cfs	- cubic feet per second
Co.	- company
DO	- dissolved oxygen
ft.	- feet
gpm	- gallons per minute(Imperial)
HEPC	- Hydro Electric Power Comm. of Ontario
Ltd.	- limited
mgd	- million gallons per day
ppb	- parts per billion
ppm	- parts per million
psi	- pounds per square inch
temp.	- temperature

	DATE DUE		